CHARACTERIZATION OF LARGE-SCALE SEQUENCE BOUNDARIES AND EROSIONAL EVENTS WITHIN THE NORTH POLAR LAYERED DEPOSITS, MARS. L. E. Steel[1] and J. W. Holt[1], [1]Institute for Geophysics, Jackson School of Geosciences, University of Texas, Austin, TX 78758 elisabeth-steel@mail.utexas.edu; jack@ig.utexas.edu.

Introduction: The North Polar Layered Deposits (NPLD) of Mars (Fig. 1) consist of ~2-km-thick water ice and dust deposits with a total volume of ~1.14 million km^3 [1]. There are many fundamental questions regarding the NPLD including the age of the deposits, compositional variations, and the processes governing their long-term evolution. A detailed accumulation history of these deposits would help answer these questions. Of particular interest are erosional unconformities that have been noted in outcrops [2] because they represent time gaps and changing environmental conditions, but it is not known whether they represent highly localized processes or large-scale events. This study examines large-scale erosional events to constrain their number, location, and extent in order to better characterize the long-term accumulation history of the NPLD.

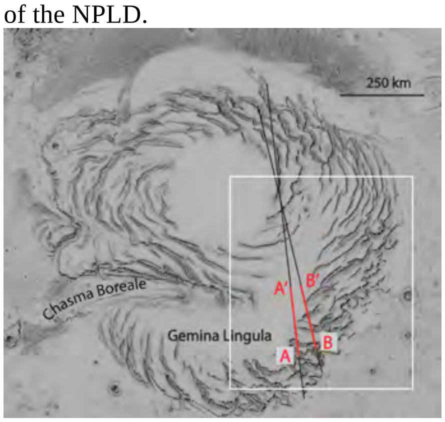

Figure 1: *MOLA hill shade map of Planum Boreum. Radargram locations for figures 2(A-A') and 3(B-B') are indicated in red. The white box indicates the location of Figure 4.*

The Shallow Radar (SHARAD) instrument onboard Mars Reconnaissance Orbiter (MRO) detects subsurface interfaces that can be mapped and used to determine stratigraphic relationships. The reflectors seen in radar profiles represent changes in dielectric properties of the material; in this case, the reflections are believed to be caused by variations in ice to dust ratios within the deposits [3,4]. SHARAD has a 10 MHz bandwidth resulting in a vertical resolution of ~9 m in water ice. Horizontal resolution is 1-3 km along track, and 3-6 km across track. This resolution allows for the imaging of truncated reflectors and stratigraphic relationships between layers on large scales.

At least two large-scale erosional events occurred in the NPLD as evidenced by unconformities in the radar stratigraphy [5]. An abundance of unconformities have also been observed using high-resolution cameras [2], but they cannot yet be positively correlated with those observed in SHARAD and may be below SHARAD's detection limit. This study focuses on the larger and possible cap-wide erosional events.

Methodology: Based on the radar stratigraphy and in a manner similar to conventional sequence stratigraphy [6], the deposits were broken into three sequences bounded by unconformities. Smaller-scale sequences (parasequences) were defined by thinner packages of bright reflectors (Fig. 2).

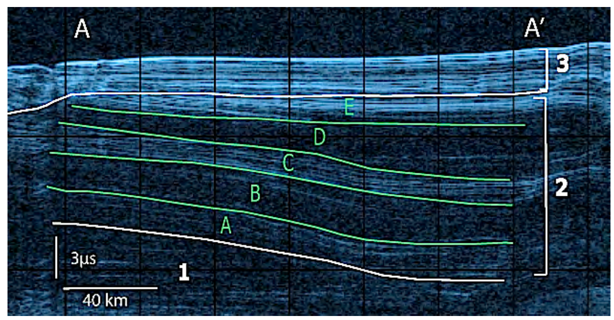

Figure 2: Radargram 594301. *Sequences 1-3 are defined by unconformities. Sequence 2 contains five parasequences (A-E) formed by thinner packages of bright reflectors. Vertical scale in two-way-time.*

Mapping of the sequence boundaries was performed using seismic interpretation software. Reflectors were mapped into truncation surfaces as well as in locations away from erosion where reflectors became conformable. Resulting maps give the geographic extent and relative depth of the unconformities.

The unconformities were mapped primarily over the region known as Gemina Lingula due to the fact that this region is relatively flat and reflectors are most continuous here (Fig. 1). More mapping is necessary in order to determine whether erosional events can be seen across the entirety of Planum Boreum.

Results: Detailed mapping of large-scale erosional events has led to the characterization of three sequences (1-3) bounded by unconformities. Sequence 2 is the thickest and contains five parasequences (A-E) defined by alternating, small-scale packages of bright and dark reflectors. These "packets" were previously noted [4,7] but placed within the same continuous sequence as our Sequences 1 and 3 (Fig. 2). The uppermost unconformity is disjointed between the high angle truncation surface observed near the outermost portion of the NPLD and the lower angle truncations observed nearer the pole. There is, however, strong evidence supporting the interpretation that these two truncation surfaces represent a single event despite our inability to directly correlate between surfaces (Fig. 3).

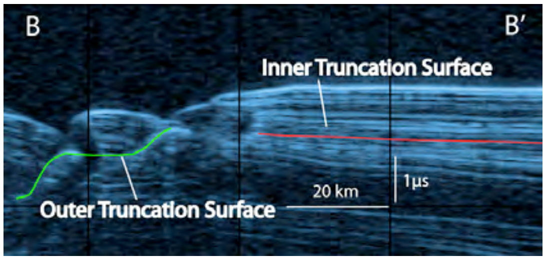

Figure 3: Radargram 488801. *The inner and outer truncation surfaces appear at the same stratigraphic level indicating that they represent one event. It can be seen that the outer truncation surface forms a much steeper angle than the corresponding inner truncation surface. Vertical scale is in two-way-time.*

Truncation surfaces for the unconformity bounding Sequences 2 and 3 were observed between latitudes 79°55’22” N and 84°03’56” N and between longitudes 15°22’42”E to 95°24’24”E. The small latitudinal range in which these truncations exist describe their localization near the edge of the NPLD. There is a possibility that truncations exist in other locations but discontinuity of layers resulting from surface topography makes continuous mapping across the cap difficult. The most severe truncations are located near the edges whereas the layers near the center are conformable (Fig. 4).

Discussion: Erosion of NPLD was most likely caused by a combination of wind erosion and solar ablation, but these mechanisms are still poorly understood. Recent work studying mass wasting events has captured high-resolution images of short-lived frost avalanches flowing down previously eroded scarps in the NPLD [8]. These mass wasting events are thought to have been triggered by wind gusts or by gas expansion related to sublimation. Surface material entrained in the events commonly includes CO_2 frost that forms seasonally [8]. Fracturing and undercutting of the basal unit (directly below the NPLD) may have caused collapse, “rockfalls,” and even fracturing in the overlying deposits that could also play a significant role in erosion of the NPLD sequences [9]. Radar profiles show a noticeable transition from low-angle to high-angle truncations nearing the edges of the deposits (Fig. 3). This steepening of the unconformable surface may be a result of mass wasting events localized on scarps at the edges of the NPLD.

The geographical extent of mapped truncation surfaces (Fig. 4) indicates that large-scale erosional events may have been confined primarily to the NPLD margins in the past. So far we have not detected any SHARAD-scale unconformities in the interior of the deposits, other than those related to trough migration [10]. This suggests that erosion preferentially occurred at the edges while continuous deposition may have occurred over the center of the cap.

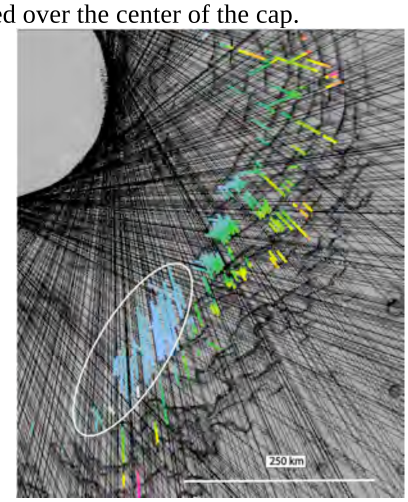

Figure 4: *Extent of mapped truncation surfaces between Sequences 2 and 3. Reflector truncations are located near edges and are not observed towards the pole. Location of inner truncation surface (Fig. 3) is indicated by white oval. Map area is shown in Fig. 1.*

Understanding the depositional hiatus represented by large-scale erosional unconformities is a necessary step towards constraining the age of the NPLD and needs to be accounted for when attempting to correlate cyclicity in the deposits to orbital cycles of known time scales. In future work, we may be able to constrain the minimum duration of these hiatuses by estimating the amount of material removed in each event and relating that to the physical processes by which erosion takes place. Such constraints will bring us closer to the goal of understanding the depositional and erosional time scales governing the long-term evolution of the NPLD.

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